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ABSTRACT

Results of recent studies into the use of concept mapping heuristic seem to demonstrate that meaningful learning results through its use in science classrooms. This study sought to find out if the metacognitive strategy of concept mapping reduces anxiety and thereby enhances achievement in biology. A total of 51 senior secondary one (grade 10) students participated in this experiment. Two instruments--the Zuckerman Affective Adjective Checklist and a Biology Achievement Test--were used in pre- and posttest administrations to measure the treatment effect on anxiety and achievment, respectively. Findings support the stand that concept mapping is significantly more effective than traditional/expository strategy in enhancing learning in biology. It has, in addition, positively affected students' anxiety towards the learning of biology. A tendency for concept mapping to significantly reduce anxiety towards biology more in males than in females was noticed. There are 29 references. (Author/YP)

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THE EFFECT OF A METACOGNITIVE STRATEGY ON STUDENTS' ANXIETY AND ACHIEVEMENT IN BIOLOGY.

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Abstract

Results of recent studies into the use of concept mapping heuristic seem to demonstrate that meaningful learning results through its use in science classrooms. While this is a boost to the need for the use of more effective instructional strategies in science teaching, the issue of an intervening variable of anxiety in learning and science achievement and the possible use of a metacognitive strategy in anxiety reduction has not been addressed.

This study, therefore, sought to find out if the metacognitive strategy of concept mapping reduces anxiety and thereby enhances achievement in biology.

A total of 51 (30 boys, 21 girls) senior secondary one students participated in this experiment. Two instruments - the Zuckerman Affective Adjective Checklist and a Biology Achievement Test - were used in a pre-and posttest administrations to measure the treament effect on anxiety and achievement respectively.

Findings support the stand that concept mapping is significantly more effective than traditional/expository strategy in enhancing learning in biology. It has in addition, positively affected students' anxiety towards the learning of biology. A tendency for concept mapping to significantly reduce anxiety towards biology more in males than in females was noticed.

Introduction

The desire to improve science achievement through more effective instructional strategies and the increasing awareness in recent years of the importance of learner-centeredness in the teaching - learning situation has necessitated a lot of attention being directed to understanding how the learner learns and how to help him learn concepts. According to Novak (1987), research has shown that few students at the secondary school or college level have had any formal instruction in how to learn. The efforts in assisting the learner to learn has led to the development of the metacognitive strategies of learning about meaningful learning (Novak, et.al, 1983, 1987; Cliburn Jr, 1987; Resnick, 1983; Gibbs, 1981; Flavell, 1976; Biggs, 1988).

The heuristic of concept mapping - an aspect of metacognitive strategies - assists learners in understanding concepts and relationships between them and seeing the hierarchical conceptual propositional nature of knowledge (Klausmeier, et.al, 1974; Novak, et. al, 1983).The proponents of the concept-mapping strategy posite that meaningful learning ensues when a learner is aware of, and can control, the cognitive processes associated with learning. Indeed, the results of some research into the use of concept-mapping heuristic seem to demonstrate that meaningful learning results through its use in science classrooms (Stewart, et. al, 1979; Novak et al,1984; Ault, 1985; Cliburn Jnr, 1987; Okebukola and Jegede, 1988,1989).

However, the issue of an intervening variable of anxiety in learning and science achievement and the possible use of a metacognitive strategy in anxiety reduction has not been addressed. And yet, various studies on the interaction between anxiety and instructional methods have revealed negative correlations between anxiety and students' achievement and the serious hampering of the total classroom functioning in relation to the realisation of important cognitive and affective outcomes (Spielberger, 1966; Sieber, et. al, 1977; Tobias, 1979; Fraser, et. al, 1983; Jegede, 1987; Jegede and Okebukola, 1988; Guadry and Spielberger, 1971). It would therefore appear that concept-mapping could be a possible means of reducing anxiety in the science classroom and hence enhancing meaningful science learning and achievement. The absence of literature in this very important area of learning calls for the need for studies to be undertaken. There is a pressing

need to find out if concept-mapping would enhance science learning through the reduction of anxiety. This might provide the much needed unequivocation (Okebukola and Jegede, 1988) in the findings of completed research into the contention of the facilitative effect of concept mapping on meaningful learning and thereby eliminate the mixed feelings (see Lehman, et. al, 1985). This study is in part an attempt to provide information to fill the gap in research in this area.

Recent research has again raised issues that touch on gender differences. Lin and Crawley III (1987) have reported that boys, more than girls, express greater leisure and career interests in science and this seems to reflect the traditionally biased stance towards science despite the different cultural background of Taiwanese. In Nigeria, Oyekan (1986) recommends the promotion of equal participation of boys and girls in science activities and clubs. Okebukola and Jegede (1987) reported, after an extensive review of literature, the tendency for scientists to conclude that scientists tend to be males; and this could mean that girls in science would exhibit a good measure of anxiety in science - an otherwise 'male domain'.
The problem therefore also relates to creating a conducive anxiety-free atmosphere for an effective biology learning and achievement for both boys and girls.

In sum, this study sought to find out if:

(i) the metacognitive strategy of concept mapping reduces anxiety and thereby enhances achievement in biology; and

(ii) gender has any significant effect on students' anxiety towards the learning of biology through the concept mapping strategy.

Methodology

Sample

A total of 51 (30 boys, 21 girls) senior secondary one (grade level 10) students of the Ahmadu Bello University Demonstration Secondary School, Zaria formed the sample of the study.
The target population of the study consisted of a total of 180 students unevenly distributed in five classes of the senior secondary one. Two classes were randomly sampled out of the five and assigned to the two groups of experimental (22 students) and control (29 students). The subjects ranged in

age between 14 years 5 months and 18 years 2 months with a mean of 16 years 1 month. All the subjects of the study take Biology as one of their science courses preparatory to the senior secondary school certificate.

Instrumentation

Anxiety was measured using a version of Zuckerman's (1960) Affective Adjective Checklist containing modifications made by Docking (1978). The instrument consists of 21 key words embedded in a total of 60 adjectives. Students are instructed to underline as many as or as few of the words which describe how they feel about learning sicnece (and in this particular case biology). The 11 words designated (+) are scored 1 if they are underlined and 0 if they are not underlined. The 10 words designated (-) are scored 0 if they are underlined and 1 if they are not underlined. The remaining 39 words are ignored in the scoring procedure. Each subject's total anxiety score is obtained by summing the scores for the 21 key words. The details of the instrument are contained in Fraser, Nash and Fisher (1983). The instrument has been found to have a good concurrent validity (with correlations of 0.62 to 0.74 with other measures of anxiety) and the KR (20) reliability co-efficient of the instrument was calculated to be 0.83 for the sample used in this study.

Biology achievement was measured using a fifty-item multiple choice instrument developed from a selection of past West African Examinations' Council assessment examination papers. The instrument was validated by a group of science educators, biology lecturers and secondary school biology teachers for correctness of content, representativeness of the biology concepts taught during the experiment and the appropriateness of the language level.

Design and Procedure

A pretest - posttest experiment with random assignment of classes to experimental and control groups was employed to examine any possible treatment effect due to exposure to the concept mapping heuristic. After this, gender and groups were crossed in a 2 x 2 factorial design, with achievement and anxiety as dependent variables, to examine the influence of gender on anxiety towards achievement in biology through the concept mapping strategy.

The experimental group was made to familiarize with concept mapping strategy for three weeks. This familiarization program consisted of lecture-discussions on concept mapping and practice sessions on how concept maps are constructed. The students were to master the major concepts of a lesson and required to list the key subordinate concepts, words and phrases that were used during class discussions on the central or superordinate concept. They were expected to arrange the concepts in a hierarchical manner beginning with the most inclusive , most abstract and general concept to the least inclusive, most concrete and specific. The next thing to do after this is linking related concepts by means of arrows and explanatory notes until a concept map was achieved with hierarchical relationships and meaningful linkages between concepts. The students concept maps constructed in each class were collected, scored and kept by the senior author. The control group had introduction to the concept through the expository manner devoid of any metacognitive strategy.

After the three weeks of familiarization, both the experimental and control groups were administered the pretests in anxiety (Affective Adjective Checklist) and achievement (Biology Achievement test) respectively. The pretests were followed immediately by six weeks of the treatment. The experimental group was exposed to teaching with each student in this group made to construct concept maps during each lesson in the class. The control group did not carry out concept mapping but was taught using the lecture method/expository approach. Both experimental and control group students were taught by the second investigator in this study. During the six week treatment, each group was exposed to three periods of eighty minutes per week.

The treatment consisted of teaching selected concepts in **Nutrition in Green Plants** and **Respiration in Cells**. These concepts were selected because they were the next set to be taught by the regular biology teacher at the time of the study. This arrangement avoided the disruption of the planned programme of study in biology for all the five classes for the term. The subconcepts taught under Nutrition consisted of anabolism, autotrophs, photosynthesis, heterotrophs, mineral nutrients and micro/macro nutrients while those taught under respiration included cellular, aerobic and anaerobic respiration and energy release.

After six weeks of teaching, the two groups were given the posttests on anxiety and biology achievement similar to the way and manner the pretests were administered.

Data Analysis and Findings

The anxiety levels and biology achievement of the experimenmtal and control group subjects before the treatment were examined for possible initial differences. The mean scores on Tables I and II and their comparison for the two groups on Table III indicated no significant differences ($p < .05$) between the control and experimental groups on the measures of achievement and anxiety. These pre-treatment tests served to establish group equivalency on the dependent variables.

TABLE I ABOUT HERE

TABLE II ABOUT HERE

TABLE III ABOUT HERE

The possible effect of the use of the concept mapping instructional strategy on the anxiety levels and biology achievement of the students after the treatment was examined by finding the mean post test scores on the anxiety measure and the achievement in biology for both experimental and control groups. The results as shown in Tables I and II indicate that the experimental group achieved a higher mean score in biology and a lower level of anxiety when compared with the control group. Statistical significances of these differences were examined further using the analyses of covariance using the pretests scores as covariates, and t-tests on the group means between the post and pre-tests for the measures of anxiety and achievement. These modes of analysis assume that the differences between the posttests and pretests are due to the effects of the treatment that occurred in between provided, ofcourse, that all other variables have been kept constant as was the case.

TABLE IV ABOUT HERE

Significant differences between the mean scores of the control and experimental groups on achievement and anxiety were found as revealed by the t-test results on Table V ($p < .01$). Evidence was also found to support significnat gender differences in the achievement of the groups and the interaction between gender and group. Similarly, significant gender differences were found for anxiety as well as the interaction between gender and group on the same measure (see Table IV).

TABLE V ABOUT HERE

The results showing significant differences ($p< .01$) in the post and pretest mean scores in the Biology Achievement Test and the Affective Adjective Test between the group taught through the concept mapping strategy and the one taught through the lecture/expository strategy, translate to mean that the concept mapping heuristic reduced students' anxiety considerably in and enhanced the learning of biology concepts.

Discusssion of Results

The study set out to investigate if the metacognitive strategy of concept mapping reduces anxiety towards, and enhances achievement, in biology and also to find out if gender differences have got any significant effects on the measures being studied.

The results obtained in the study seemed to suggest that the concept mapping strategy has enhanced learning in biology more effectively than the traditional expository and has positively affected students' anxiety towards the learning of biology. Secondly, significant gender diferences were noticeable in the effect of concept mapping heuristic on students' achievement and anxiety towards biology. There was a tendency for the concept mapping strategy to significantly reduce anxiety towards biology achievement more in males than females.

The enhanced learning achieved through the concept mapping strategy as revealed by this study is in agreement with earlier findings of Novak, et. al

(1983); Novak and Godwin (1984); Ault (1985); Cliburn Jnr (1986, 1987). the results of this study disagree with those of Lehman et. al (1985) and tilt the balance of the argument of the effectiveness of concept mapping over other strategies towards its unequivocal superiority. What to our mind seemed very important to biology instruction and therefore very significant contribution to studies on metacognition, as this study has shown, is the capability of concept mapping strategy in significantly enhancing as well as reducing the negative effect of anxiety.

It would seem therefore that concept mapping promotes meaningful learning and probably depresses anxiety through this mechanism. According to Ausubel (1963) meaningful learning is promoted by the understanding of the hierarchical relationships and linkages between concepts. This is the main target of the concept mapping heuristic in which students are taught to identify the network of relationships between concepts rather than as discrete isolated entities favouring rote learning. It may well be that the constant use of the metacognitive strategy makes the students feel very comfortable and stabilizes their emotional state when working within intricate and interconnected systems of thought. This explains why concept mapping depresses anxiety levels towards the learning of biological concepts.

The significant effect of gender on achievement through the use of the concept mapping heuristic in this study supports the findings of some researches which indicated that the use of some modern methods of instruction seems particularly unsuitable for girls (Ruman, 1977; Grayhill, 1975; Lynch and Peterson, 1980). It may well be that the metacognitive strategy of concept mapping has something to contribute to the search for a solution to combat the apparently insurmountable differential gender performances prevalent in learning and achievement in science and technology.

The second significant finding from this study is the differential effects between males and females in the reduction of anxiety levels engendered by concept mapping. The results showed that females were more anxious than the males as the mean scores on Table II showed inspite of the fact that the sample was taught by a female teacher. Even as the pretest results showed, females were more anxious than the males. The higher anxiety level noticed in the females should be seen within the context of the pressures the society exerts on females who opt to study science in a 'male-dominated' society in which science is seen as masculine (Jegede and Okebukola, 1989). In

tradtional societies, women are neither heard nor regarded as equal to men. Females are seen as threat when they attempt to pursue the study of science subjects of their natural inclinations. The treatment with contempt, and the very low socio-cultural status the females studying science receive may be a contributory factor. There may therefore be a need to look more closely into what environmental variables (both in and out of the classroom) contribute to raising the levels of anxiety particularly in females (Jegede and Okebukola, 1988).

It is necessary to consider the findings of this study alongside some factors. First, the small sized-one-sample design of this study and secondly, the probable effects of the confounding variables usually associated with study designs of this nature may have introduced some forms of threats of external validity.

As a result, therefore, while the significant conclusions of this study might contribute relevantly to research on concept mapping and anxiety, their interpretations must be done cautiously. Undertaking a similar but more rigorous study with a view to eliminating any confounding variables would boost the generalizability of the conclusions and hence their incorporation in biology teaching.

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TABLE I

Means and Standard deviations on the Biology Achievement Pretest and Posttest scores for groups and gender.

	Control				Experimental			
	Male (N=16)		Female (N = 6)		Male (N = 14)		Female (N = 15)	
	X	SD	X	SD	X	SD	X	SD
Pretest	36.00	7.04	36.00	7.15	36.71	7.14	36.6	5.51
Posttest	37.50	7.32	36.33	7.10	55.33	8.42	49.06	12.84

TABLE II

Means and Standard deviations on the Anxiety Pretest and Posttest scores for groups and gender.

	Control				Experimental			
	Male (N=16)		Female (N = 6)		Male (N = 14)		Female (N = 15)	
	X	SD	X	SD	X	SD	X	SD
Pretest	8.90	2.89	10.10	2.01	8.71	2.54	9.06	3.65
Posttest	8.01	3.09	10.50	2.07	5.39	2.18	6.06	2.64

TABLE III

Summary of the ANOVA on the Pretest mean scores of the control and experimental groups on the Biology Achievement and Anxiety Tests

Source of variation	Sum of squares	DF	F	Sig. of F
Achievement				
Group	2.08	1	.08	.83*
Group x Gender	21.56	1	.69	.42*
Anxiety				
Group	7.69	1	.08	.77*
Group x Gender	12.76	1	.15	.74*

* not significant at $p < .05$

TABLE IV

Summary of the ANCOVA on the Posttest scores mean of the control and experimental groups on the Biology Achievement and Anxiety Tests using Pretests as Covariates

Source of variation	Sum of squares	DF	F	Sig. of F
Achievement				
Group	77.46	1	7.83	.01*
Gender	41.24	1	3.44	.02*
Group x Gender	98.96	1	6.06	.01*
Anxiety				
Group	77.46	1	6.19	.02*
Gender	68.86	1	9.51	.01*
Group x Gender	36.11	1	4.99	.03*

* significant at $p < .05$

TABLE V

Summary of t-Tests of the Pretest and Posttest means scores for the control and experimental groups in the Biology Achievement and Anxiety Tests.

Variable	Group	DF	Mean diff.	S.D	T-value	p<
Achievement						
Posttest Vs Pretest	Control	21	.91	3.01	1.21	.31
Posttest Vs Pretest	Experimental	28	17.24	18.66	8.70	.001*
Anxiety						
Posttest Vs Pretest	Control	21	1.00	3.03	1.54	.14
Posttest Vs Pretest	Experimental	28	3.01	13.05	6.15	.001*

* significant at p< .05